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Notes on some new or little known North American Limnæidæ. By A. G. Wetherby, A.M. (Journ. of the Cincinnati Soc. Nat. Hist., July, 1879.) Pages 8. From the author.

A Monograph of the Silurian fossils of the Girvan district in Ayrshire, with special reference to those contained in the "Gray Collection." By H. Alleyne Nicholson and Robert Ethridge, Jr. Fasciculus II. (Trilobita, Phyllopora, Cirripedia and Ostracoda.) 8vo, pp. I-IV, 137-233, pls. x-xv. Wm. Blackwood & Sons, Edinburgh and London, 1879. From the publishers.

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## GENERAL NOTES.

### BOTANY.

SEXUAL DIFFERENTIATION IN *EPIGÆA REPENS*.<sup>1</sup>—The following remarks on *Epigæa repens* are contained in Gray's "Synoptical Flora of North America," under the generic description of that plant:

"The flowers are heteromorphous and inclined to be diœcious, or diœcio-dimorphous. Those with fully polliniferous anthers seldom set fruit; their stigmas short, erect, slightly projecting beyond the margin of the five-toothed ring (to the teeth of which they are severally adnate), the style sometimes longer than the stamens and projecting, sometimes shorter and included. Fully fertile flowers on other plants; their styles (as in the former sort sometimes long and exserted, sometimes shorter and included) with stigmas elongated and much surpassing the ring, short, linear, glutinous, radiately divergent; their stamens either slightly polliniferous, or reduced to abortive filaments, or even wanting."

In the early spring of this year I took occasion to make some careful observations on this plant as it occurs in the vicinity of Washington City, the results of which, though in the main confirmatory of this description, differ from it in some respects, and afford some additional facts of special interest.

I desire to premise that these variances and additional peculiarities are doubtless due to differences of habit in different localities, and not to any lack of fidelity in description.

The principal deviation which I detected from the description which I have quoted, was in the styles and stigmas. I found no heterostyly; the length of the styles relatively to the flowers was about the same at all times in both forms of flowers. The stigma, however, presented a very different appearance in one form from what it did in the other. In the fertile form, in which the abortive stamens varied in all degrees, the lobes of the style were strongly divergent and of a firm texture, with evident stigmatic surfaces. In the staminate form they were never separated, but cohered tightly in an apparently solid club-shaped summit or head. I was able, however, to dissect them apart without

<sup>1</sup>Read before the American Association for the Advancement of Science, at Saratoga, N. Y., September 1, 1879, by Lester F. Ward, A.M.

lesion, and satisfy myself that they were entirely functionless, possessing no stigmatic surfaces.

The important *addition* which my observations furnished to the facts described by Prof. Gray, consisted in the discovery that the dimorphism of the flowers extends in a marked degree to their *dimensions*. The staminate flowers are, in all respects, much larger than the fertile ones. As this fact at first appeared quite remarkable, I took great pains to verify it, making my comparisons from specimens taken from localities widely separated, and repeating the observations a great many times throughout the flowering season of the plant. It grows on gravelly slopes in small areas or patches, and all the flowers in a patch were invariably found to be of the same kind, either all staminate or all fertile, as if all came from the same root, as no doubt they do.

The amount of surface covered by staminate plants was found greatly to exceed that covered by the fertile ones. It thus often required considerable search to find a patch of fertile flowers, but a little practice was sufficient to render their detection easy from the diminished size and conspicuousness of the flowers. This difference does not consist merely in the greater vigor and turgidity of the staminate form, but represents an actual discrepancy in the measurements of all the parts of the flower, amounting to about thirty per cent. in the length and about forty per cent. in the width of the corolla. The exact dimensions, as taken from typical specimens, were as follows:

Length of flower including calyx and limb of corolla:		
In staminate form.....	16	millimeters.
In fertile form.....	12	"
Width of corolla tube split through and laid open:		
In staminate form.....	11	"
In fertile form. ....	7	"
Width of limb of corolla laid open in the same manner:		
In staminate form.....	15	"
In fertile form.....	9	"
Length of the pistil, including ovary and stigma:		
In staminate form.....	9	"
In fertile form....	7	"
Length of perfect stamens.....	9	"
Length of sterile filaments.....	3	"

The staminate form appears never to develop fruit, although the ovary contains ovules. The fertile form, besides being much more rare in actual amount at flowering time, and possessing decidedly less fragrance, also often fails to fruit. It is, therefore, only quite rarely that fruiting specimens can be found. I attribute this, however, to the failure of most of the fertile flowers to receive any pollen. The two forms are often not in close proximity. They bloom very early in the spring, before most of the flying insects appear. The flowers are always close to the ground, with their open end more frequently inclining downward than upward, and most of them are concealed under the foliage so as to

be invisible from above. Yet, as we have seen, their self-fertilization is impossible. These and other facts have led me to the conclusion that, where fertilized at all, it is chiefly done by ants, which, on the theory, now generally accepted by entomologists, of the possession by that insect of a keen sense of smell, would sufficiently account for the exquisite fragrance of the flowers of *Epigæa*. I have failed entirely to find insects within the corolla, but this, so far from causing doubts that it is fertilized by insect agency, simply helps us to understand why it bears fruit so sparingly.

The facts which I have stated, even if they were entirely new, which they probably are not, might not, perhaps, in themselves have justified me in claiming for them the attention of this association. For my own part I am far more interested in the important principles which they illustrate, and it is for the purpose of stating these principles, supported by such an example, that I have been led to present the facts.

Besides affording an instructive example of the many ways in which plants are dependent upon insects, *Epigæa* well illustrates the process of sexual differentiation which is going on in a great many species of plants. In the maples it has not yet advanced so far; in *Smilax* it has gone somewhat farther, while in the willow it has reached completeness. It is in these intermediate stages that the phenomena are most interesting, and the botanist, contemplating a great number of these, differing by small degrees, can almost see the process in operation. The phenomena of dimorphism, as it exists in *Houstonia*, must probably be regarded as one of the initial steps in the direction of ultimate diœcism, or complete separation of the sexes.

In this respect, as in many others, we find that nature cannot be assumed to have reached its final and fixed condition, but that the existing state of things must be regarded as dynamic; the movements in the past which have made things what they are, still continue to effect changes in them. There is a sort of *uniformitarianism* in biology as well as in geology, and the law of "present causes" is as potent in explaining the existing condition of plants and animals as it is that of coast lines or mountains.

Hermaphroditism, or self-fecundation, seems to be a thralldom necessary at the outset, but from which all living things are seeking to escape. The animal kingdom has, for the most part, thrown off this yoke, chiefly through the development of the sexual instinct. The vegetable world still groans heavily under it, but it is now looking to insects as its liberators, and the little flower which I have figured here, shows one of the many ways in which these creatures perform this service.

THE AGENCY OF INSECTS IN FERTILIZATION.<sup>1</sup>—I present some additional notes taken from papers prepared by some of my young students while working under my direction.

Mr. A. J. Chappell studied a healthy plant of *Lythrum salicaria*. The flowers of the species are trimorphous. The plant studied was one which produced short stamens and those of medium length and a long style. In the bud, these organs are bent or curved so that the anthers and stigmas are included within the calyx. The anthers all ripen at about the same time, sometimes before the flower opens.

Bees visit the plant freely. Their heads are covered with pollen from the stamens; the thorax with pollen from the stamens of medium length.

Some of the pollen thus collected on the insect is carried to the long pistils. Pollen was found on all the stigmas, but Mr. Chappell observed *that after a few days each pistil in turn after the flower had opened, wilted and fell off.*

Mr. E. A. Murphy found several kinds of insects about the *Lythrum* above mentioned. He was also surprised to see all the pistils, after they had been exposed for a few days, wilt and fall off. The plant was making a fair growth, and did not suffer from dry weather or a surplus of moisture.

Mr. J. T. Elliott studied *Apocynum androsaemifolium*. The anthers are shaped somewhat like an arrow-point. All the anthers form a sort of pyramid about the pistils. An abundance of honey attracts many insects. The groove between the lobes of the anthers often catch and hold small bees by the tongue, much as a tapering crack between two boards would hold a rope. Small wild bees pull out the masses of pollen which come in pairs.

Some flowers were tied up to keep all insects away. In some cases after a few days, the bell-shaped corolla was full and overflowing with nectar. These were artificially fertilized, some with pollen of the same flower; others with pollen from other flowers. Some were kept covered without artificial aid in transferring pollen. All were covered again. Those pistils where the stigmas were supplied with pollen set fruit.

Mr. W. A. Burgess tried similar experiments with similar results.

Mr. J. H. Irish observed the flowers of catmint. When the anthers are discharging their pollen, they are clustered around and a little above the pistil. When the pistil is ready to secure the pollen, it reaches above the stamens and spreads its stigmas apart. At this time the anthers are dead and slightly curled down. The stigmas are just in position to touch the back of an insect where it has previously collected pollen from anthers of a younger flower.

<sup>1</sup> Notes from some of the papers of students at Michigan Agricultural College. Abstracts made by Prof. W. J. Beal.

In several cases, flowers were tied up with sarles which kept insects away. No seeds set.

Insects fertilize *Nepeta nuda* in the same manner as they do the catmint.

Mr. Geo. Young found that the flowers of *Nepeta mussini* were also proterandrous and that they were fertilized essentially in the same way as the two species above mentioned. He sprinkled some chalk dust on the back of a bee and soon found that it had come back for more honey. *Salvia Japonica*, *Teucrium Canadense*, thyme, and motherwort were fertilized in the same manner.

A number of spikes of *Teucrium* before flowering were tied up in bags. None of these set seeds. Other spikes were tied up in a similar way. The latter were several times violently shaken without taking off the covers. This caused about one-fifth of the flowers to set seeds.

The fertilization of *Plantago lanceolata* and *P. major* have before been described. The flowers are in spikes. The pistils appear some time before the stamens which are long and reach some distance up the spike. The pollen is dry and the plant is usually described as dependent on the wind for aid in transferring from one flower to another.

Several students have seen honey bees and other wild bees, bugs and flies in considerable numbers about the flowers of *Plantago lanceolata*. These insects, except the bugs, seem to be after the pollen.

Mr. Avery covered buds of *Asclepias cornuti* and they set no fruit. Not all insects about this plant aid in the fertilization. He saw some insects held fast by pollen which they were not stout enough to pull out. Some left their legs and had escaped. Ants get fast sometimes. They were seen to liberate their feet with their jaws.

Mr. L. Wilcox found the flowers of the common teasel proterandrous and dependent on various insects for fertilization.

Mr. H. I. Penoyer finds that the flowers of *Mimulus ringens* are not self-fertilizing but depend on the aid of insects. Detailed experiments were made to prove the statement.

Mr. J. E. Coulter removed the young stamens from flowers of *Scrophularia nodosa* and found that the pistils were fertilized in some way by receiving pollen from other flowers. He also tied up some flowers with paper bags and found that they did not set fruit. Mr. J. R. Shelton removed the stamens from five opening buds, and tied over them a paper bag. After a few days they began to enlarge and develop seeds. He covered five buds not artificially fertilized and they set no fruit. This plant is proterandrous and well described and illustrated in Dr. Gray's neat little book, "How Plants Behave."

Mr. W. E. Hale found that the flower buds of *Campanula rotundifolia* all blasted if tied in paper sacks. It has often been

shown that the stamens shed their pollen on the outside of the style before the stigmas are open.

Mr. W. H. Goss tied paper sacks about flowers of *Lobelia spicata*; none of them bore seeds. From others he cut away the young anthers while very small. The latter were left exposed and all fruited.

Mr. C. A. Ward, on the flowers of *Martynia proboscidea* has seen bumble bees, honey bees and another wild bee. Bumble bees were seen to enter the flowers. The stigmas closed before the bees backed out. The quickest time observed for the closing of the stigmas was *three seconds*. It took this six minutes to open again. The longest time for closing of stigmas was twelve seconds, and this occurred on a cool, cloudy day. He says, "It always took twice as many minutes to open as it did seconds to close. After about five trials made in succession, the stigmas refused to act, as if they were tired out."

Mrs. F. A. Gulley, during two weeks of very hot, dry weather, watched a patch of white clover, every day at different times, and never saw an insect near it. At the end of that time, she examined fifty of the heads, twenty-eight of which had no seeds. In the other twenty-two heads there were two or three, and sometimes five or six of the flowers which contained seeds. Previous to dry weather, bumble-bees were abundant on the flowers and these seeded freely.

Mr. E. A. Burke studied the flowers of Indian corn. In nearly all cases, the pollen begins to fall two or three days before the stigmas appear. The first pollen is discharged from the central spike of the tassel and last at the base of the lower or side spikes. The plant sheds pollen continuously for five to eight days. Small bugs seem to be after the pollen.

Mr. A. C. Redding also studied Indian corn. In forty-eight cases out of fifty, the staminate flowers appeared from two to three days before the pistillate flowers. The anthers shed pollen within twenty-four hours after they appeared. The pistils are ready to be fertilized in a few hours after they appear. To prove this, he tied cloths over the whole ear after the pistils had been out for a few hours. In each case the ovules developed. He also tied up some before the stigmas appeared and fertilized them artificially. The kernels all set.

Bees, wasps and other bugs visit the stamens. If the stigmas are soon ready for fertilization after they appear, they are in nearly all cases crossed by pollen from other stalks.

Mr. A. G. Jack observed the flowers of *Epilobium coloratum*. It is well known that *E. angustifolium* is proterandrous or at least most of the stamens are ripe before the stigmas appear. The former plant under consideration has four petals which are two-lobed. It has eight stamens, four of which are long and four short. The four long stamens grow up close to the stigma and

adhere to it, where they discharge their pollen before withering. The four short stamens grow only about half way to the stigma. At no stage of their growth could he find them any longer. Both sets of stamens discharge their pollen at the same time. The short stamens are attached to the base of the petals and when the flowers close, the petals coming together draw the anthers of the short stamens up to the base of the stigmas. Occasionally a small green bee came to the flowers, but they all left at once, as though they had made a mistake. He tied up buds before they were open, and found that the flowers all set seeds freely.

Mr. C. H. Osband finds that the sensitive stigmas of the flowers of trumpet-creepers close in about three seconds after being touched and open in five minutes. Both insects and humming birds aid in fertilization.

THE FUNCTION OF CHLOROPHYLL.—One of the most important recent contributions to physiological botany, is contained in a recent communication to the Berlin Academy of Sciences, by Dr. Pringsheim, which appears to throw considerable fresh light on the function of chlorophyll in the life of the plant.

Having been led by previous researches to the conclusion that important results might be obtained by the use of intense light, he combined an apparatus by which the object under view should be brightly and constantly illuminated by a strong lens and a heliostat. If in this way an object containing chlorophyll—a moss-leaf, fern-prothallium, chara, conferva, or thin section of a leaf of a phanerogam—be observed, it is seen that great charges are produced in a period varying from three to six or more minutes.

The first and most striking result is the complete decomposition of the chlorophyll, so that in a few minutes the object appears as if it had been lying for some days in strong alcohol. Although however, the green color has disappeared, the corpuscles retain their structure essentially unaltered. The change then gradually extends to the other constituents of the cell; the circulation of the protoplasm is arrested; the threads of protoplasm are ruptured and the nucleus displaced; the primordial utricle contracts and becomes permeable to coloring matters; the turgidity of the cell ceases; and the cell presents, in short, all the phenomena of death.

That these effects are not due to the action of the high temperature to which the cell is exposed under these circumstances is shown by the fact that they are produced by all the different parts of the visible spectrum. The result is the same whether the light has previously passed through a red solution of iodine in carbon bisulphide, through a blue ammoniacal solution of cupric oxide, or through a green solution of cupric chloride. If the carbon disulphide solution of iodine be so concentrated that only rays of a greater wave-length than 0.00061 mm. can pass through it, these effects are not produced, although about eighty per cent. of the heat of white sunlight is transmitted. On the other hand, if the



ammoniacal solution of cupric oxide be so concentrated that the whole of the rays of a less wave-length than 0.00051 mm. are absorbed, a rapid and powerful effect is produced, although the amount of heat that passes is very small. It is thus seen that the phenomena in question are not the result of heat.

The next point determined by Dr. Pringsheim, is, that the effects are not produced in an atmosphere devoid of oxygen. This was the case whether the oxygen was replaced by pure hydrogen or by a mixture of hydrogen and carbon dioxide; while the removal of the carbon dioxide from atmospheric air was altogether without effect on the phenomena. The conclusion drawn is that the decomposition of chlorophyll in the living plants is a process of combustion which is influenced and promoted by the action of light, and which is not related to the decomposition of carbon dioxide by the plant. When the green color of the chlorophyll-grains has been partially destroyed, it cannot be restored, even though the cell continues to live; from which it is inferred that the result is not a normal physiological, but a pathological effect. No substance was found in the cells which might be regarded as the product of the decomposition of the chlorophyll, nor was any oil or starch detected in the etiolated cell, nor any formation of grape-sugar or dextrine. The assumption is therefore that the products of decomposition are given off in the gaseous form.

The conclusion is drawn that the decomposition produced in the protoplasm, and in the other colorless cell contents, is the direct effect of the photochemical action of light. That it is not due to the injurious influence of the products of decomposition of the coloring matter of the chlorophyll, is shown by the fact that it takes place equally in cells destitute of chlorophyll, such as the hairs on the filaments of *Tradescantia*, the stinging hairs of the nettle, &c. It is, on the other hand, dependent on the presence of oxygen, or is a phenomenon of combustion.

The results of a variety of experiments leads Dr. Pringsheim to the important and interesting conclusion that the chlorophyll acts as a protective substance to the protoplasm against the injurious influence of light, diminishing the amount of combustion, or, in other words, acting as a regulator of respiration.

He then proceeds to investigate what are the substances which become oxidized in the process of respiration. In every cell, without exception, that contains chlorophyll, Pringsheim finds a substance that can be extracted by immersion in dilute hydrochloric acid for from twelve to twenty-four hours, to which he gives the name *hypochlorin* or *hypochromyl*, and which he believes to be the primary product of the assimilation of the chlorophyll. It occurs in the form of minute viscid drops or masses of a semi-fluid consistency, which gradually change into long red-brown imperfectly crystalline needles. It is soluble in alcohol, ether,

turpentine and benzol, but insoluble in water and in a solution of sodium chloride. It becomes gradually oxidized on exposure to an imperfectly crystalline resinous substance. It is probably an ethereal oil, and an invariable accompaniment of the coloring substance of chlorophyll, and even more universally distributed than starch or oil. It has not yet been detected in those plants which do not contain true green chlorophyll, such as the Phycochromaceæ, Diatomaceæ, Fucaceæ and Florideæ. Starch and oil appear to be reserve substances produced by the oxidation of the hypochlorin caused by light, it being the most readily oxidizable constituent of the cell, more so even than chlorophyll itself.

That the hypochlorin—present in variable quantity in every chlorophyll grain under normal circumstances—is subject to continual increase and decrease, may be proved without difficulty. All comparative observations on chlorophyll grains in younger and in older conditions, point unmistakably to the conclusion that the collection and increase of the starch enclosed in the ground substance of the chlorophyll, goes on *pari passu* with a decrease of the hypochlorin. In dark, the hypochlorin, which does not take any direct part in the transport of food materials, is more permanent than starch; and this fact again is in agreement with the conclusion that its transformation in the cell into more highly oxidized bodies is hindered by the increased respiration in light.

In the facts here detailed, and the conclusions derived from them, Dr. Pringsheim believes that an entirely new light is thrown on the cause of the well-known fact that assimilation takes place only in those cells of the plant which contain chlorophyll. This substance acts universally as a moderator of respiration by its absorbent influence on light, and hence allows the opposite phenomena of respiration and elimination of carbon dioxide to go on in those cells which contain it. A more detailed account of the experiments and results is promised by the author in a future paper.—*Alfred W. Bennett.*

### ZOOLOGY.<sup>1</sup>

BUNDLES OF SNAKES.—The statements made by Humboldt as to the piles of snakes he saw in Guiana, can be verified here in our northern woods and swamps. I personally had the pleasure of observing it twice, both times very early in spring, and in locations which could be called wildernesses. I first saw such a bundle of snakes in the neighborhood of Ilchester, Howard Co., Md., on the stony bank of the Patapsco river, heaped together on a rock and between big stones. It was a very warm and sunny location, where a human being would scarcely disturb them. I reasoned that the warmth and silence of that secluded place

<sup>1</sup> The departments of Ornithology and Mammalogy are conducted by Dr. ELLIOTT COUES, U. S. A.